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Poster paper

Improvement in Bragg crystal bender design for a polychromator

T. R. MAIRS, J. BORREL† AND O. MATHON
ESRF, 6 Rue Jules Horowitz, BP 220, 38043 Grenoble, France

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A new design for a polychromator Bragg bender at ID24 Dispersive EXAFS beam-line (ESRF) shows improvements in stability, in the shape of the bent crystal and in the efficiency of adjustments to find the best focal spot.

1. Introduction

The precision and stability of the curvature of the Bragg crystal in the polychromator is critical for the quality of experimental data. The adjustment of the focal spot onto the sample at each change of energy has been very time consuming for scientists coming to European Synchrotron Radiation Facility (ESRF) for only few shifts.

Repeatability and possible automation were the goals we wanted to meet when it was decided to upgrade the polychromator of the ID24 beam line at ESRF.

1.1. *Beam-line layout*

The ID24 optical schematic (figure 1) shows where the polychromator is located. The aim of the device is to produce polychromatic focused beam onto the sample. Typical focused beam size is 5 μm × 5 μm. That focus is done by two vertical focusing mirrors, one at 30 m of the source and the other close to the sample. The horizontal focusing is done by one horizontal elliptical focusing mirror at 32 m from the source and the polychromator.

1.2. *Polychromator principle*

In the Bragg configuration, polychromatic beam is provided, in the range of 3.5–15 Kev, by bending a silicon crystal (111, 220 or 311) to reach at the focus point, a range of monochromatic beams provided by X-ray coming with an angle of incidence between the two angles theta1 and theta2 (figure 2).

To bend the crystal we chose a four-pin bender (San Miguel *et al.* 1998; Pellicer *et al.* 1998). The crystal is in contact with two fixed pins on the concave side. The two other pins turn around each fixed pin by the means of lever arms actuated by stepper motor jacks. They bend the crystal by applying a moment at either end. If the two moments are the same, the shape is cylindrical. If the two moments are a bit different, the shape can be elliptic, as in our case.

† Email address for correspondence: borrel@esrf.fr

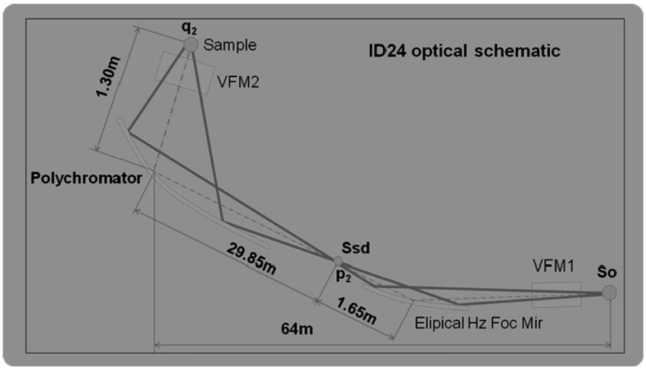

FIGURE 1. ID24 Optical schematic.

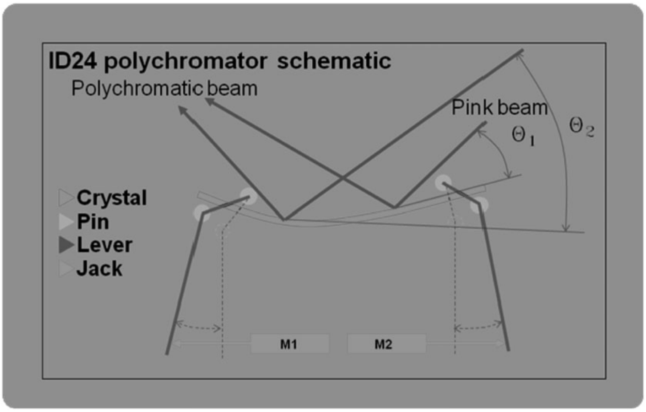

FIGURE 2. Polychromator schematic.

2. The design

The design of the new Bragg bender had to follow such requirements as: shape of the curvature must be as stable as possible, repeatability should be around few μm for actuators and twist correction should be independent of the bending movement (figure 3).

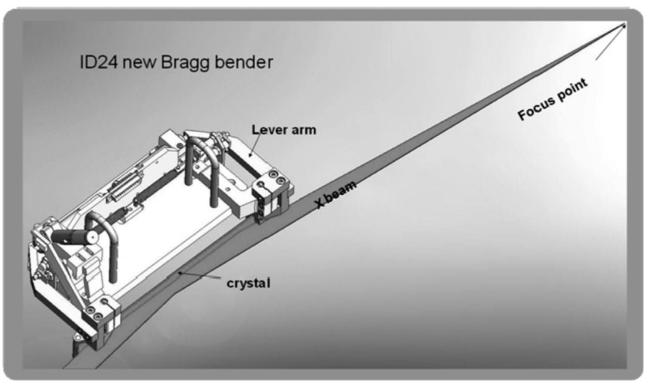

FIGURE 3. New Bragg bender.

2.1. *Stability*

The stability of the curvature has been achieved by using two C-flex pivots, on each side. They are mounted in a way such that no influence of the force from the jack providing the rotation through the lever arm gives parasitic movements in the other directions (figure 4).

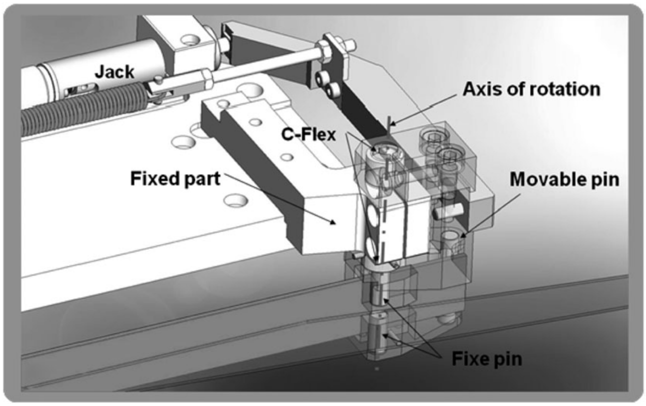

FIGURE 4. Bending arm design.

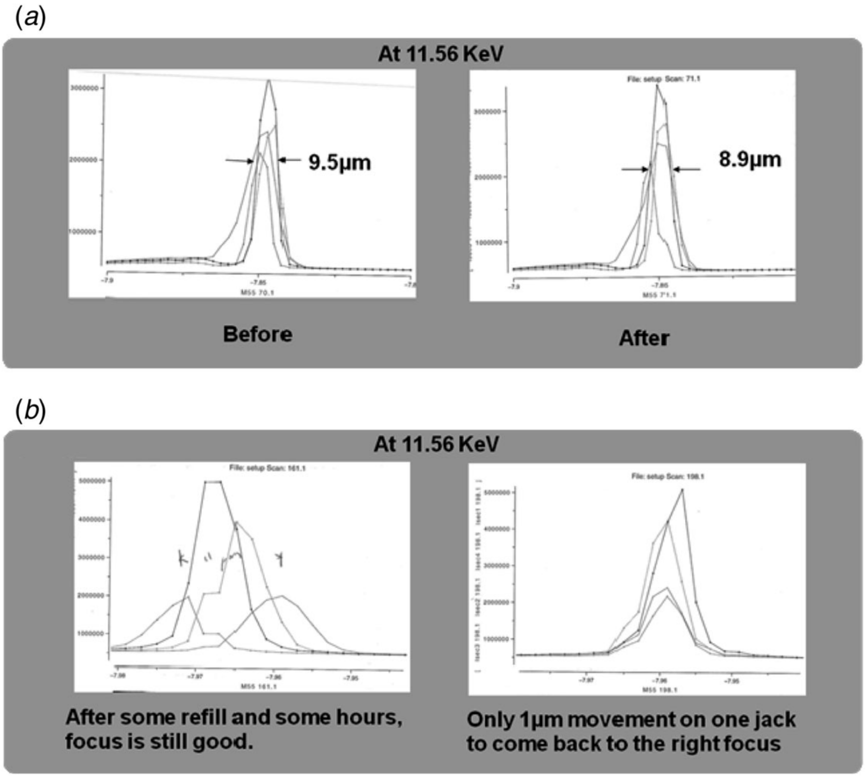

FIGURE 5. Focal spot measurements.

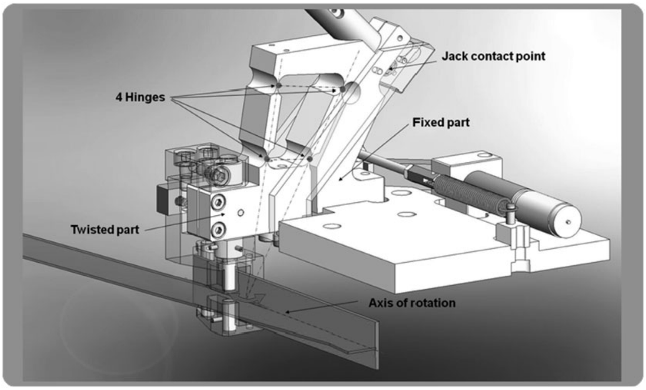

FIGURE 6. Twist correction design.

2.2. *Repeatability*

Repeatability is achieved by designing a kinematic system without play. The jacks, which were designed by ESRF, are non rotating head and the contact surface of the lever arm is in sapphire. Typical bidirectional repeatability of the jacks is 150 nm.

Tests have been performed in the metrology laboratory at ESRF. The results show that bidirectional repeatability is around 1–2 μm, measured at the middle of crystal curvature.

Tests made on ID24 with the beam (figure 5*a*,*b*) show the dimension of the focused spot for each quarter of the polychromator measured at the sample position:

(i) The repeatability test (figure 5*a*): gives only 0.6 μm FWHM change in the focal spot that is visible after −50 and +50 μm movement of one jack.

(ii) Stability test (figure 5*b*): after some hours only 1 mm is necessary to refine the focus.

2.3. *Twist correction*

Twist correction has been achieved by choosing new flexure geometry (figure 6). Instead of only one hinge with lever arm that induced modification of the curvature of the crystal when it was used, the choice has been made to put the axis of rotation on the middle of the crystal to decouple twist correction and bending. The geometry of the flexure is four hinges in a shape where the centre of rotation of each hinge describes a trapezium. The centre of rotation of this system is defined by the intersection of the segments of the trapezium that are not parallel. This geometry is very stiff in the other directions.

3. Conclusion

Further development: In the future design of the Bragg polychromator in the EDSAX-S of the ID24 upgrade programme, attention will be paid to facilitate the mounting of the bender into the chamber by using a kinematic mount.

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